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NATURAL HISTORY AND CONSERVATION STATUS OF THE TAMARUGO CONEBILL IN NORTHERN CHILE

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Abstract.—I studied Tamarugo Conebill (*Conirostrum tamarugense*) populations at the Pampa del Tamarugal National Reserve in northern Chile between October 1993 and July 1994. The estimated population of conebills was 35,107 individuals in 10,787 ha of tamarugo forests. A strong relationship was found between forest foliage volume per hectare and breeding conebill density. The Tamarugo Conebill breeds in the tamarugal September–December and then probably migrates to the highlands of southern Perú. Although the species' breeding locality presently is protected, it faces some important threats including the pumping of the subterranean aquifers upon which the tamarugal vegetation depends, attempts to control the butterfly upon whose larvae the species forages, and human disturbance on the wintering grounds. *Received 15 May 1995, accepted 30 Nov. 1995.*

The western slope of the Andes, comprising the arid regions of northern Chile and southern Perú, is one of 57 areas of high avian endemism in South America (Bibby et al. 1992b). Among the birds of this region, the Tamarugo Conebill (*Conirostrum tamarugense*) is one of the rarest species, and has been known to science only since 1969 (Mayr and Vuilleumier 1983). The species was formally described by Johnson and Millie (1972) from six specimens collected at the Pampa del Tamarugal, northern Chile. Afterward, the few documented records of the species (see McFarlane and Loo 1974, McFarlane 1975, Tallman et al. 1978, and Schulenberg 1987) have provided little information about its natural history and general status. All records are of solitary individuals or small groups, generally in mixed flocks with the Cinereous Conebill (*C. cinereum*) (McFarlane 1975). Thus far, there have been no estimates of its population size, habitat requirements, or seasonal movements. Recently Estades and López-Calleja (in press) have reported the nesting of the species at the Pampa del Tamarugal. The conservation status of the Tamarugo Conebill is uncertain, and the Chilean Forest Service (CONAF) considers it "insufficiently known" (Glade 1988). More recently Rottmann and López-Calleja (1992) considered the Tamarugo Conebill as "vulnerable," while Collar et al. (1992) also categorized the species as "insufficiently known" in the list of threatened birds of the Americas.

The present paper reports on an assessment of the conservation status of the Tamarugo Conebill (*C. tamarugense*) in northern Chile. The objectives of the study were to obtain estimates of the species' population

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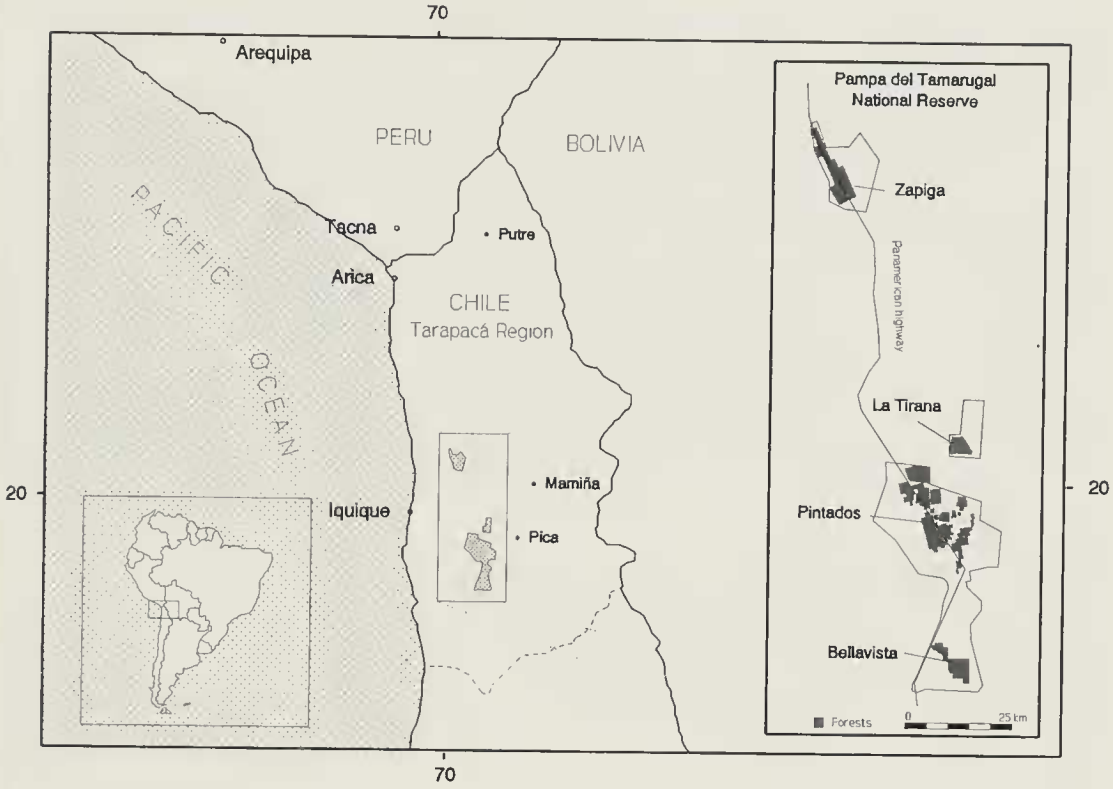

FIG. 1. Geographical location of the study area.

size, describe its habitat requirements, assess its seasonal movements, and determine principal threats to its survival.

STUDY AREA AND METHODS

I studied conebills at the Pampa del Tamarugal National Reserve (20°24′S, 69°44′W) in the Tarapacá Region, northern Chile (Fig. 1). This area, at an elevation of 1000 m, has an extreme dry climate with a mean annual rainfall of 0.3 mm (di Castri and Hajek 1976). Annual temperatures range between an absolute minimum of −12°C and a maximum of 35°C. Relative humidity undergoes wide daily fluctuations (3–8% during the day to 80–100% during the night in October; Sudzuki 1985). The Pampa del Tamarugal is a vast salt flat over subterranean aquifers. It is dominated by savannas of tamarugo (*Prosopis tamarugo*), a highly drought-resistant tree. Shrub and herbaceous layers are almost nonexistent, with only scattered individuals of *Atriplex atacamensis, Tessaria absinthioides, Caesalpinia aphylla,* and the extreme halophyte *Distichlis spicata* (Gajardo 1994). During the last four centuries, the Pampa del Tamarugal was intensively exploited for the production of firewood and charcoal, mainly to support the mining industry. This cutting drastically reduced the extent of the tamarugo forest, leaving few remnants of forest, mainly low density stands of little economic interest. In the 1930s, a reforestation program was started, which by the 1970s had generated 14,600 ha of tamarugo plantations (Aguirre and Wrann 1985). In addition, approximately 1900 ha of algarrobo (*Prosopis alba*) plantations were established at the Reserve. In 1983 the administration of the plantations passed to the Chilean Forest Service which created the 109,842-ha Pampa del Tamarugal National Reserve (Fig. 1). Since its creation, the reserve has been used for the production of forage for sheep which feed on

tamarugo pods, for the production of firewood and charcoal, and, occasionally, for the production of lumber.

I visited the Pampa del Tamarugal three times between October 1993 and July 1994. The first visit (25 Oct–2 Nov) was during the austral spring, the second (14–21 March) during late summer, and the third (19–26 July) during mid-winter. The reserve is divided into four major areas: Pintados, Bellavista, La Tirana, and Zapiga (Fig. 1). Due to time constraints, only the first three plots were assessed. These areas were selected for the following reasons: Pintados is the largest stand and holds the oldest tamarugo plantations, Bellavista is at the southern limit of the Reserve and might correspond to the southern limit of the Tamarugo Conebill's range, and the La Tirana plot holds the last natural tamarugo stands.

In order to estimate population densities 18 line transects were established at Pintados and six at Bellavista in the spring of 1993. Because no birds were found at La Tirana during the surveys, no transects were established and density was considered to be zero. Three of the transects at Pintados were located in a 60-ha managed stand. The trees of the latter stand had been pruned in 1991 for the production of timber and charcoal. As a result of this management, these trees lacked almost the entire lower half of their foliage. Additionally, four transects were surveyed at an algarrobo plantation at Pintados.

The transects used were of the "fixed belt" type (Bibby et al. 1992a). In each transect, all the birds seen or heard between two rows of trees were counted. Thus the width of the belt was two times the distance between tree rows. Because this distance was different between years of planting (10, 13.5 or 15 m) the length of the transects varied from 300 to 200 m, in order to equalize the surveyed areas. Preliminary observations carried out in the afternoon (i.e., after 13:00 h) consistently gave lower densities than observations in the morning. Therefore, all surveys were made between 7:00 and 12:00 h. Transects were surveyed 3.1 times, on average, during the first visit.

During March and July 1994, four of the transects at Pintados were surveyed a total of eight times per visit in order to compare densities between seasons. The other transects were not formally assessed.

Habitat along transects was characterized in terms of foliage volume per ha. The estimation of each tree's volume (m^3) was based on the formula volume = $(0.5 \text{ diameter})^2 \times \text{pi} \times \frac{2}{3}$ height. The estimated dimensions of the trees were total height, crown diameter, and presence or absence of the lower third of the foliage. To convert the results to volume per ha, the number of trees in the transect was recorded.

To describe the patterns of microhabitat use by foraging conebills, I divided trees visually into six sections. The parts of the tree that contained the leaves and flowers were separated from those that consisted of leafless branches, and the tree was divided into three horizontal layers. All observed birds were assigned to the section in which they were first observed. Individuals were captured in mist nets and banded to study the species' migratory movements. Finally, non-systematic observations were made to expand knowledge of the species' general natural history, both in the reserve and in adjacent localities. Mean densities were compared among seasons using one-way ANOVA. The effect of tamarugo pruning on bird density was assessed using a *t*-test.

RESULTS

Population size.—Densities derived from transects were calculated separatedly for the different types of tamarugo forests surveyed during spring 1993. During this period, many conebills were observed throughout the tamarugo plantations but at varying local densities (Table 1). No individuals were found at La Tirana. The total estimated conebill popu-

TABLE 1

DENSITIES (IND/HA) AND POPULATION SIZES OF TAMARUGO CONEBILL IN PAMPA DEL TAMARUGAL NATIONAL RESERVE, NORTHERN CHILE, DURING OCTOBER 1993

Stand	Stand age	Stand area (ha)	Conebill density mean (SD)	Total population
Pintados	46	964	9.27 (2.85)	8940
Pintados	27	2881	4.84 (3.23)	13,947
Pintados	21	4833	2.38 (3.39)	11,517
Bellavista	21	2109	0.33 (1.49)	703
All stands	—	10,787	3.25 (0.68[a])	35,107[b]

[a] Weighted mean's standard deviation (Cochran 1980).
[b] 95% confidence interval: 18,970–51,244; 11.3 degrees of freedom.

lation was 35,107 individuals. At Pintados, significant differences were found between conebill densities in different seasons (Fig. 2). Densities declined ($F = 74.37$, df = 2, $P = 0.000$) over time from a high of 8.3 ind/ha in October 1993 (breeding season) to almost no birds at all in July 1994 (nonbreeding season).

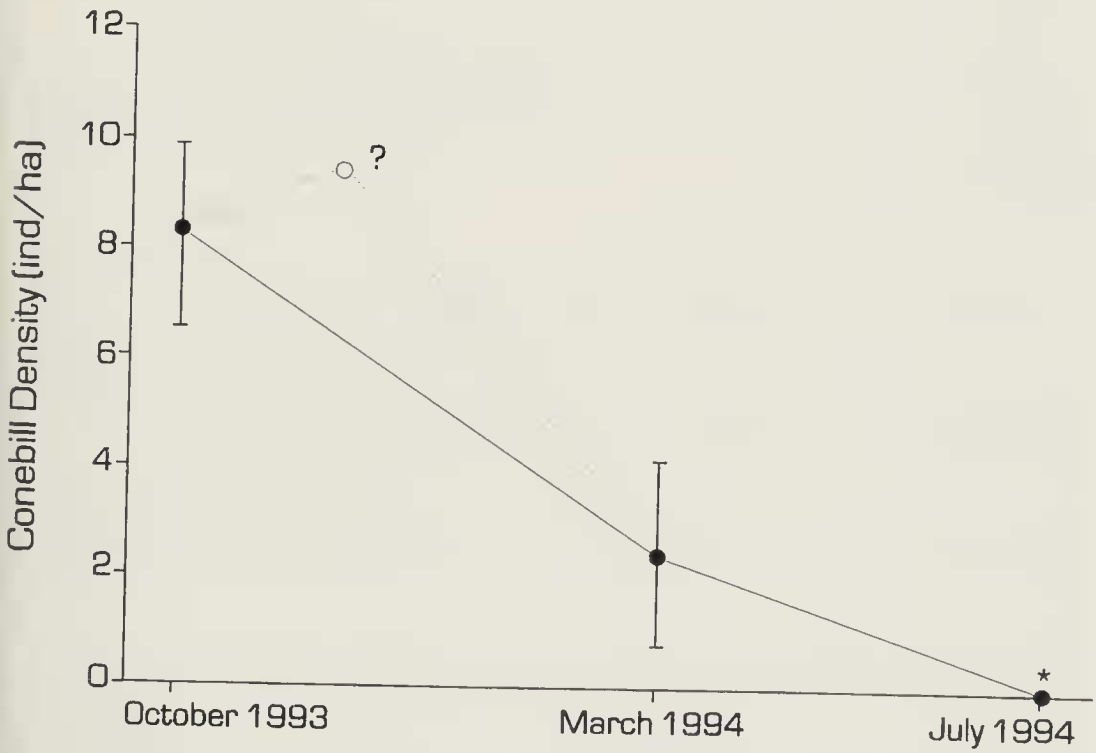

FIG. 2. Mean conebill densities (±SD) on four transects in a 46-year-old forest stand at Pintados for three periods. The empty circle with the interrogative symbol represents the possibility that the population had increased in November–December due to the addition of first-year birds following the breeding season. The asterisk indicates individuals were observed in the area, but none was recorded on the transects.

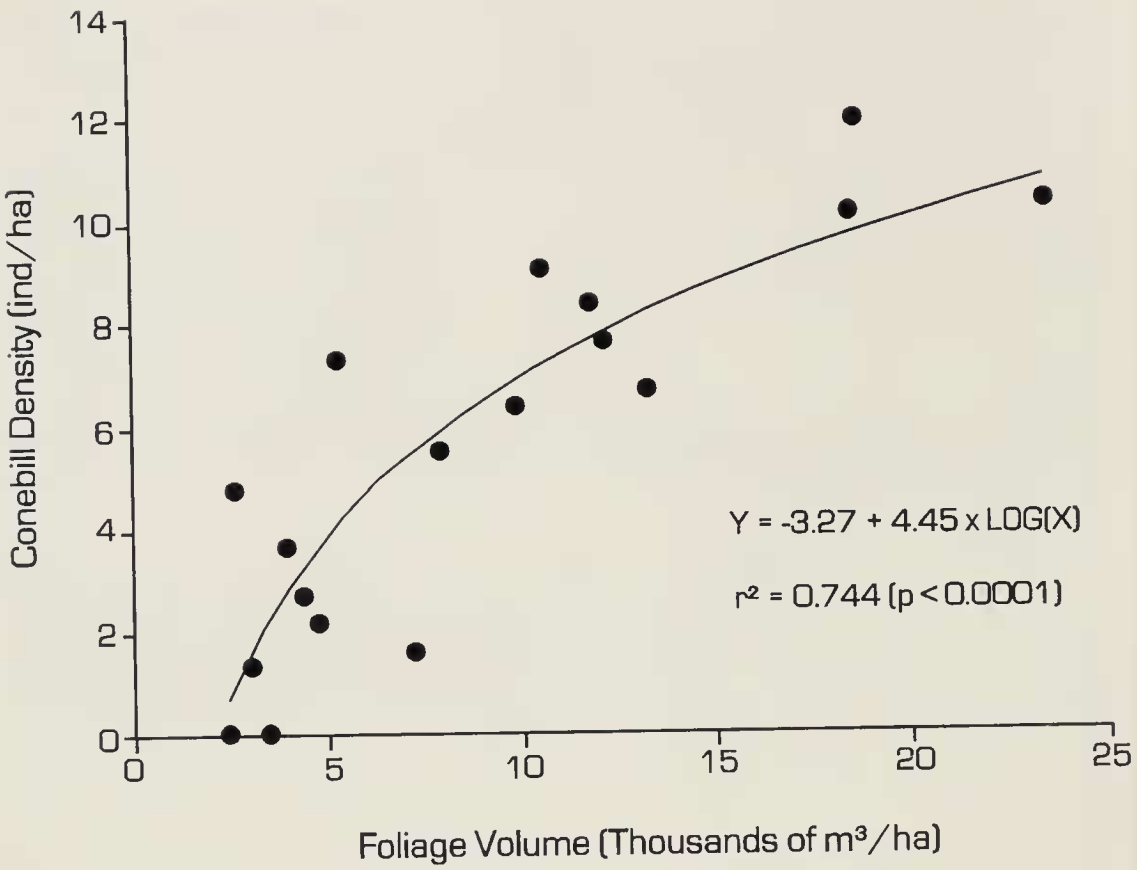

FIG. 3. Relationship between tamarugo foliage volume per ha and conebill density during October (breeding season) 1993 at Pintados. Points represent the mean conebill density on each transect.

Habitat use.—A significant relationship was observed between forest maturity and density of breeding conebills (October 1993). At Pintados, a high percentage of the variance ($r^2 = 0.744$; N = 18; $P < 0.0001$) of conebill density is explained by the total foliage volume (Fig. 3). Surveys of algarrobo plantations show that the Tamarugo Conebill does not use this forest type; on the four transects, no individuals were seen (October 1993). During the breeding season, the managed stand at Pintados held a significatively lower density of conebills than the unmanaged stands (*t*-test, $P = 0.0000$).

The species was found wintering (July 1994) at the localities of Pica and Mamiña (see Fig. 1). At the first site, a few individuals were observed foraging with *C. cinereum* in *Citrus* plantations. The same situation was found at Mamiña, where conebills were foraging in mixed flocks in riparian scrubs of *Baccharis petiolata* and *Tessaria absinthioides*.

Microhabitat use.—During the breeding season, the Tamarugo Conebill showed a marked tendency to use the outer and upper parts of tamarugo

FIG. 4. Percent of sightings of conebills in each tamarugo microhabitat zone.

trees (Fig. 4). The species was observed foraging mainly on Lepidoptera larvae, specifically on the species *Leptotes trigemmatus* Butler (Lycaenidae) which feeds on tamarugo leaves, buds, and flowers (Cogollor et al. 1982). Conebills preferentially selected the descending terminal branches of the trees for nesting (Estades and López-Calleja, in press). In the oldest forests, breeding pairs held territories that included only a few trees around the nest tree. During the nonbreeding season, the species did not show a clear pattern of microhabitat use at Pampa del Tamarugal. At the other sites surveyed, the species foraged mainly inside the scrub.

Because conebills principally used the upper half of tamarugo trees for foraging, I thought that the removal of the lower half of the crown (as a result of the pruning of the trees in the managed area) might have little impact on the birds, but their density was lower in the managed stand. The hypothesis that pruning created microclimatic changes that may have affected the habitat suitability of the trees was tested. In July 1994 air temperatures were measured at ground level and at 1.5 m and at 4.5 m at the center of 15 pruned and 15 non-pruned trees and then averaged. Data were collected at 7:00 and 12:00 and repeated over two days. No significant differences were found between pruned and non-pruned trees at 7:00 h (t-test, $P = 0.635$). At 12:00 h, mean temperature was significantly lower at the pruned plot (t-test, $P = 0.009$), probably due to the convective cooling of wind.

Breeding.—The nesting of *C. tamarugense* was first recorded at Pintados in October 1993, austral spring (Estades and López-Calleja, in

press). These authors found several active nests and presented evidence that the species has been breeding at the Pampa del Tamarugal for many years.

Breeding success was not evaluated. However, during March 1994 (late summer), conebills at the reserve were observed flying in small flocks composed of approximately 60% adults (individuals with the rufous superciliary line, throat, upper breast, and undertail coverts) and 40% immatures. The only juvenile conebill captured was slightly smaller than the adults and showed a dirty grayish color instead of the characteristic rufous pattern.

During July 1994 (winter), very few individuals were observed at the reserve (0–6/day). It was not possible to determine their age since all were seen from a distance. However, many of the conebills observed at the Mamiña oasis lacked the rufous adult color.

DISCUSSION

Habitat and distribution.—Even though *C. tamarugense* is not restricted to tamarugo forests (McFarlane 1975, Tallman et al. 1978, this report and several personal communications), the species depends on this type of vegetation for breeding. Moreover, given the high concentration of individuals and reproductive activity (Estades and López-Calleja, in press) and the absence of significant tamarugo forests outside the reserve, it seems possible that most, if not all, of the species' population breeds in this area. Maturity of the forest seems to be an important factor in determining the habitat suitability for conebills. The strong relationship between foliage volume per hectare and the density of breeding conebills parallels patterns described by Mills et al. (1991). Considering that the number of flowers and the density of larvae in these flowers at Pintados are correlated positively with tamarugo foliage volume (López-Calleja and Estades, unpubl. data), the relationship between conebill density and foliage volume (Fig. 3) suggests that, above a certain foliage volume, conebill density could be limited by territoriality instead of availability of food. Below approximately 2000 m^3 of foliage per ha, the tamarugo forest is not a suitable habitat for the Tamarugo Conebill (Fig. 3). This hypothesis could explain the absence of the species at La Tirana. Even though foliage density was not formally assessed at this site, it was clearly below 2000 m^3, as trees are separated by 30 m or more in this area.

Low density of conebills at Bellavista could be explained by the scarcity of *Leptotes* larvae feeding on tamarugo flowers there (López-Calleja and Estades, unpubl. data). This situation could be due to the high degree of isolation of the plot which may reduce immigration of these butterflies.

The high proportion of time spent by the species at the top of trees

(see Fig. 4), might be mainly due to the concentration of flowers and *Leptotes* larvae there, rather than a territorial behavior. In fact, breeding conebills, instead of singing from high branches, call constantly while looking for food, as stated by Fjeldså and Krabbe (1990).

Johnson and Millie (1972) and Tallman et al. (1978) suggested that the Tamarugo Conebill could be a high-altitude species that breeds during the summer (highlands breeding season), then in winter moves into lowlands of Tarapacá until the spring (late lowlands breeding season). Our present study does not support this hypothesis, indicating instead that breeding occurs at Pampa del Tamarugal between September and December during the tamarugo flowering and the outbreak of *Leptotes trigemmatus* larvae. Individuals may then move upwards (to 2500–3500 m) and to the north, following a chain of small, mid-elevation, vegetated valleys. Possibly a small group could also migrate to the north from or through Zapiga to the lowlands of Arica, where the species has been observed (McFarlane 1975) (Fig. 5). Given the results of this study, isolated individuals or small flocks of the species seen in lowlands near Arica during the breeding season (Sept.–Nov.; McFarlane 1975, Sallaberry pers. comm.) are probably wandering, nonbreeding birds. This uncommon pattern of migration would enable the species to use an important food resource almost exclusively during its breeding period (no other bird species was observed foraging on *Leptotes* larvae at the Pampa del Tamarugal) and thereafter to share seasonally rich food resources with the species of the highlands of northern Chile and southern Perú during their breeding season (Jan.–March).

It is possible that some conebills could remain near the Pampa del Tamarugal during the entire year, since in May–June the tamarugos have a second flowering period ("devareo"). However, the extent and intensity of this phenomenon seems to be insufficient to support a large conebill population.

Conservation status.—The relationship observed between the vegetation and Tamarugo Conebill density suggests that, in the year of the species' discovery (1969) the oldest of the reforested forests (which then had a mean age of 23 years) were just beginning to provide a suitable habitat for the species, allowing its populations to reach a level that permitted detection by ornithologists. This hypothesis implies that the present population of the species is derived from a small number of individuals that survived a major population decrease during the period of deforestation at Pampa del Tamarugal.

My estimates for the total population of *C. tamarugense* at the study area are larger than any of the general estimates for minimum viable populations (see Shaffer 1987). In addition, assuming that the relationship

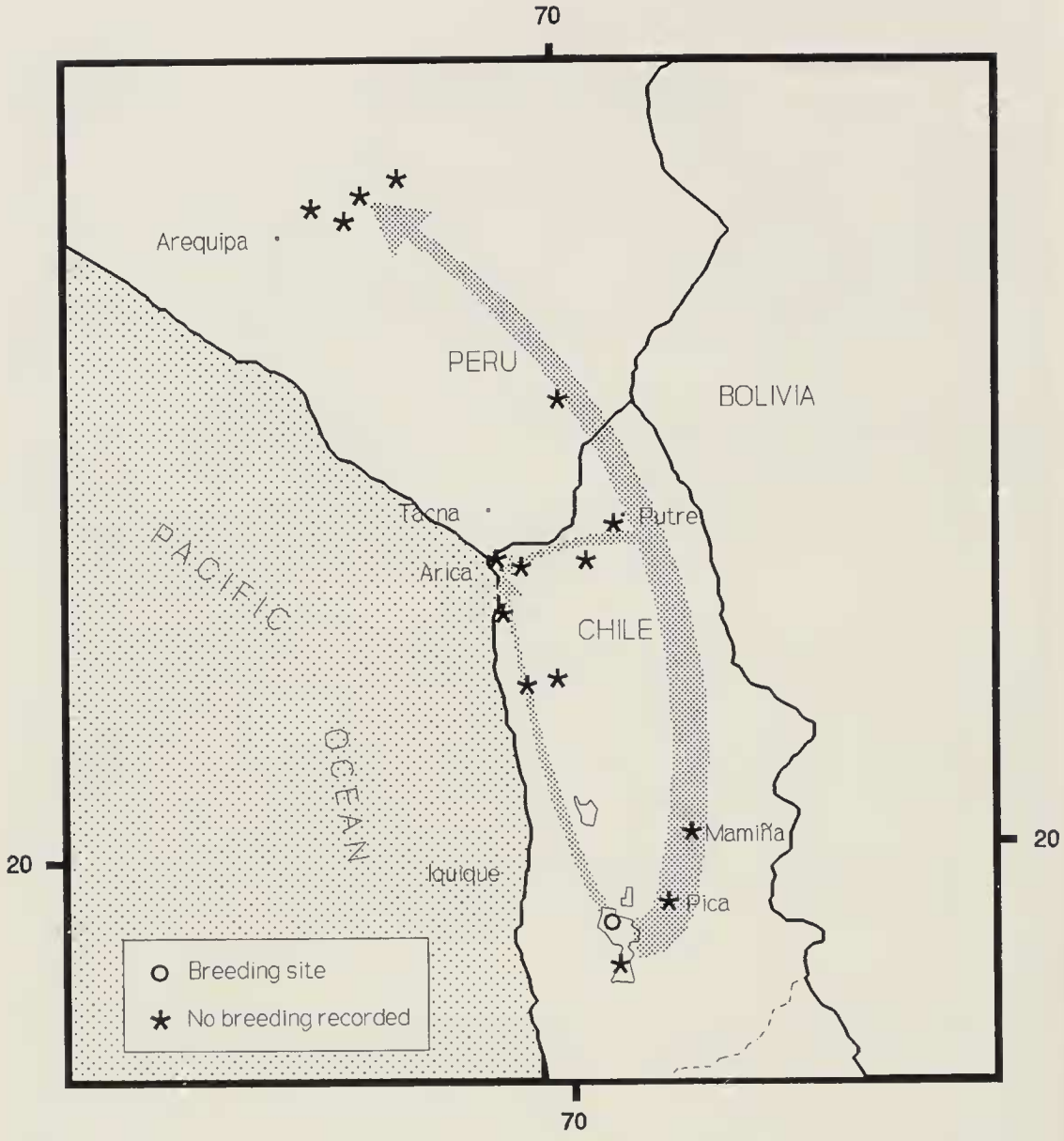

FIG. 5. Known localities (symbols) and hypothetical migratory movements (arrows) of *C. tamarugense*.

between vegetation and conebill density will not change during future years, the total population of the species should increase with the forest volume as younger plantations mature. However, even if Tamarugo Conebill populations are increasing and viable, there are at least three major threats that could reduce the species' short-term survival probability. (1) Presently the tamarugo is still managed mainly for production of sheep forage (pods) and for production of timber and charcoal, and pruning of trees reduces habitat suitability for conebills. However, management techniques could be modified in order to reduce the negative impact on the

birds. The threat of forage production is quite different, because management attempts to control populations of *Leptotes trigemmatus,* which feed on flowers and drastically reduce the yield of pods. Initially it was intended to control the species by using chemicals (Cogollor et al. 1982). At present, the Chilean Forest Service is studying the use of parasitoid microhymenoptera as an alternative way of control. The success of such a control program could, without doubt, be extremely harmful for conebill populations. (2) Since the mean annual rainfall in the area is 0.3 mm, the only water available for the tamarugos are the subterranean aquifers that are found beneath the Pampa del Tamarugal. At present, these waters are pumped at a rate of 700 lts/sec (CONAF rangers, pers. comm.) in order to supply the requirements of the city of Iquique (see Fig. 1). The ecological consequences of this water removal are not known. It is not clear whether these aquifers are recharged by rainfall in the mountains, or if they are "fossil" waters. In the last few years, there has been an increasing number of dead trees observed at several sites in the reserve. However, this phenomenon has been related to an excessive salt accumulation within the xylem vessels rather than to water deficit (Donoso et al. 1989). (3) Almost all localities where *C. tamarugense* has been observed, out of the Pampa del Tamarugal National Reserve, seem to lack of any type of legal protection. During the non-breeding season, the Tamarugo Conebill has been reported foraging in sites dominated by tree species such as *Polylepis,* shrubs such as *Gynoxys* in Perú (Tallman et al. 1978), and scrub (*Tessaria, Baccharis*), trees (*Schinus*) and cultivated species (*Citrus*) in Chile (McFarlane and Loo 1974, McFarlane 1975, this study). Even though there are no direct threats to conebill populations at the species' wintering localities, all these areas are characterized by extreme aridity, and there is increasing human disturbance (e.g., *Polylepis* cutting). The security of the species' wintering grounds is, therefore, uncertain (Collar et al. 1992).

I suggest the following: (1) To give the species the IUCN conservation status of "Vulnerable," as suggested by Rottmann and López-Calleja (1992). Further research and population monitoring should continue to clarify its status. (2) To stop or limit the control of *Leptotes trigemmatus.* An economic assessment would be necessary in order to estimate the cost of not controlling this insect. (3) To study the short- and long-term effects of tamarugo management strategies on conebill populations in order to design management techniques that best benefit all tamarugo users. (4) To study the effects of water pumping on the survival of Tamarugo Conebills.

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